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Determination of MIL-H-6083 Hydraulic Fluid In-Service Use Limits for Self-Propelled Artillery

Prepared by
Constance Van Brocklin

Report Date
September 1991

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Belvoir RD&E Center

United States Army
Belvoir Research, Development and Engineering Center
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MIL-H-6083 hydraulic fluid from M109A3 and M110A2 Self-Propelled Howitzers of the III Corps Artillery, Ft. Sill, OK, was sampled and analyzed at regular intervals over a 21 month period. The laboratory data was correlated with fluid age, vehicle log data, and available Army Oil Analysis Program (AOAP) data. The purpose of this program was to determine the in-service use limits of MIL-H-6083 in Self-Propelled Howitzers. No discernible deterioration was detected in the fluid samples with ages up to 32 months. Most samples had high water levels and excessive particulate contamination. No useful correlation of fluid condition test results with AOAP test data was found. The Navy Patch Kit method for particle contamination measurement was evaluated as a possible field test method for ground vehicles.

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US ARMY TROSCOM

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Table of Contents

Section I
Introduction

The useful service life of hydraulic fluid in armored vehicles is needed to eliminate unnecessary hydraulic fluid changes and to eliminate damage to hydraulic systems caused by deteriorated hydraulic fluids. Because of a lack of data correlating hydraulic fluid properties with the age and usage history of the hydraulic system, fluid change policies have been established for individual armored vehicles which range from extremely conservative to nonexistent. For example, some lube orders recommend that the hydraulic fluid be changed every 6 months, while others require no changes and no testing, thus allowing the fluid to remain in the vehicle for the entire life of the hydraulic system.

To establish in-service use limits, baseline data is required showing the physical property changes of the hydraulic fluid along with the vehicle's usage history. Operational vehicles with hydraulic fluid of known ages were needed for testing on a regular schedule. The data would be used to determine a sensible change interval for the hydraulic fluid based upon easily measured physical properties or a standard time interval.

Since at least two military hydraulic fluids—MIL-H-6083[1] (OHT) and MIL-H-46170[2] (FRH)—are used in various pieces of military equipment under varying conditions, it is clear that information for the different fluids in specific pieces of equipment should be determined before any generalizations concerning change intervals for all hydraulic fluids in all pieces of equipment can be made.

The Fort Sill, OK, III Corps Artillery was approached to cooperate in this program since it is a source of self-propelled artillery being used in regular Army environment. Personnel from the III Corps were willing to provide test vehicles and personnel to draw samples and provide the accompanying vehicle log data for the program. The Belvoir Research, Development and Engineering Center (BRDEC), Materials, Fuels and Lubricants Directorate, Fuels and Lubricants Division, provided guidance, hydraulic fluid sampling containers, and testing of the samples. MIL-H-6083 is the hydraulic fluid used in the M109A3s and M110A2s participating in the program.

Section II
Approach

The purpose of the testing program was to develop meaningful in-service use limits and to provide information for establishing standard drain/replacement intervals and procedures for OHT hydraulic fluid being used in self-propelled artillery.

A total of 17 M109A3s and M110A2s from several battalions were selected for participation in the program. It was essential that each participating Howitzer have hydraulic fluid of known age at the beginning of testing so the properties of the aging fluid could be tracked by fluid age, hours of service, and miles driven. Hydraulic fluid samples were drawn every 6 months and sent to the Fuels and Lubricants Division for testing along with hours of service, mileage, fluid replenishment, and other miscellaneous information. The Test Plan is included as Appendix A.

Appendix B is a listing of participating vehicles with their fluid ages, mileages, hours of service, and firing data. The beginning fluid age was unknown for several of the vehicles. In these cases, the age is indicated as "00+month" to show that the age is at least 0 months, or "13+months" to indicate that the fluid is at least 13 months old. Since there is very little data on "old" hydraulic fluid, these samples can provide valuable information to support conclusions on hydraulic fluid aging, even though their data cannot be used to indicate the condition of fluid on an absolute age. A few vehicles required a complete fluid change during the program because of a hydraulic component change or by Army Oil Analysis Program (AOAP) direction. The fluid age reflects this action.

Section III
Test Results

After 18 months of testing, no discernible trends of hydraulic fluid deterioration were apparent in fluid samples up to 32 months old. Most fluid properties, except fluid cleanliness, remained within the limits of the MIL-H-6083 specification for new fluid. Most hydraulic fluid samples were very dirty, far exceeding the MIL-STD-1246, Level 200 [3] cleanliness standards established for the vehicles (see Appendix C). Appendix D lists typical values and specification limits for new hydraulic fluid. Appendix E is a tabulation of all laboratory data for each vehicle. Appendix F lists most the data by fluid age to highlight any trends. A discussion of each of the tests and results follows.

WATER CONTENT

The percentage of water was determined using the American Society for Testing and Materials (ASTM) D1744 Karl Fischer Reagent method. The specification limit is 0.05% (500 parts per million). Only 20 of the 62 fluid samples met this limit. Excessive water promotes corrosion and breakdown of the corrosion inhibitor, so water should be carefully controlled.

TOTAL ACID NUMBER

The acid number was determined by the ASTM D664 potentiometric titration test method. Unfortunately, data were not obtained in October 1989 and May 1990 due to an equipment malfunction. There were no significant differences in the acid number values for the samples analyzed. An increase in acid number indicates a breakdown of the hydraulic fluid additives and a buildup of corrosive by-products.

GALVANIZED CORROSION

A few samples were tested for galvanic corrosion, determined by Federal Test Method Standard (FTM) 791C, method 5322, to check for the development of corrosive by-products or deterioration of the corrosion inhibitors. No galvanic corrosion was detected.

VISCOSITY AT 40°C

Kinematic viscosity was determined by the ASTM D445 method. There were no discernible changes in viscosity. This type of hydraulic fluid may suffer a decrease in viscosity as the viscosity index (VI) improver is broken down (sheared) through usage.

STEEL-ON-STEEL WEAR

Steel-on-Steel Wear, the 4-Ball Wear Test, was performed according to ASTM D4172 on about half of the fluid samples. A discernible trend was not confirmed, although additional testing of older samples may show that the wear scar diameter increases as the fluid age increases. Appendix G presents a graph of fluid age and wear scar diameter showing the possibility of a trend. This test correlates well with full scale pump tests in determining the ability of a fluid to protect metal components from wear.

SOLID PARTICLE CONTAMINATION, GRAVIMETRIC METHOD

Fluid samples were filtered through 0.45 micron filters to measure the total amount of solid particulate contamination according to ASTM F313. Hydraulic fluid must be ultra clean to protect sensitive hydraulic components. Even fluid samples with no visible contamination may be excessively contaminated. In addition, dirt and water contribute to the premature breakdown of the hydraulic fluid, and abrasive particles cause wear of sealing materials. The fluid specification limit is 0.5 milligram per 100 milliliters of hydraulic fluid. Only two of the 62 samples met this limit. Many were 10 or 20 times this amount; several were not determined since the contamination was excessive, with visible seeds and other debris. It is possible that at least some of the contamination was introduced during sampling. This type of excessive contamination causes wear and failure of hydraulic components. Usually, these failures are not catastrophic so that the true cause of failure is not traced to the condition of the hydraulic fluid.

PARTICLE SIZE DISTRIBUTION

The solid contaminants were also determined on the automatic particle counter for most samples. Samples with excessive contamination were not determined because of potential damage to the automatic particle counter. This data confirmed the gravimetric data which showed contamination exceeding many fluid cleanliness standards. The hydraulic fluid cleanliness standards shown in Appendix C are BRDEC's fluid cleanliness standards for construction, earthmoving, and material

handling equipment; MIL-STD-1246B, Level 200[3], the hydraulic fluid contamination limit for all new and rebuilt M109 models; NAVAIR 01-1A-17,[4] the widely used Navy technical manual for aviation hydraulics; and NAS 1638, a 1964 document of the Aerospace Industries Association of America, Inc., which provides cleanliness requirements for parts used in hydraulic systems. Most Fort Sill samples exceeded all of these standards.

Section IV
Correlation with AOAP Data

The AOAP was designed to analyze engine oil samples to detect unusual wear before a major failure occurs. This spectrometric analysis of the hydraulic fluid can measure metallic wear particles in the hydraulic system which could indicate an imminent failure. However, this method does not measure large quantities of non-metallic solid contamination in the hydraulic fluid, which is a major cause of hydraulic system failures. The crackle test used by AOAP labs to measure water contamination in adequate for engine oil samples, but not for hydraulic fluid, although it does indicate excessive water and has some value.

Hydraulic fluid test data from the AOAP were obtained so that correlations with the physical property data from the Use Limits Testing Program could be made. Appendix H lists all available AOAP data. Since AOAP sampling of hydraulic fluid is required annually, it would be desirable to correlate hydraulic fluid deterioration with data being obtained in AOAP testing. Most samples were not sent to the AOAP lab the same day they were taken, so few direct comparisons could be made. An attempt to correlate AOAP silicon values with gravimetric data was unsuccessful. It appears there are no useful correlations between the Use Limits Testing Program data and the AOAP data.

Section V
Hydraulic Fluid Patch Test

The US Navy uses a Hydraulic Fluid Contamination Analysis Kit for testing aircraft hydraulic fluids aboard ship where laboratory hydraulic fluid analysis is not available. This kit is described in technical manual NAVAIR 17-15E-52.[5] A 100 milliliter hydraulic fluid sample is filtered through a 5.0 micron filter (the "patch") and then the color of the patch is compared to known color standards for a fast go/no-go test of the cleanliness of the hydraulic fluid. The color standards range from white to varying shades of grey or white to varying shades of tan. The color standards correspond to the NAVAIR 01-1A-17[4] Particle Contamination Level Classes. Classes 1 through 5 are acceptable and Class 6 and above unacceptable for aircraft (Appendix C). Unacceptable hydraulic fluid must either be cleaned in a purifying unit or a complete flush-and-fill is required. The patch kit technique is appealing since it is inexpensive, simple to perform in the field, and quite reliable for the high cleanliness standards required for Naval aircraft.

Since this type of patch kit testing could easily be used for monitoring hydraulic fluid samples from ground vehicles, Fort Sill hydraulic fluid samples were filtered through 5.0 micron filters to gather data useful to assess the patch kit method for armored vehicles. The patches were retained for comparison with the Navy color standards and with other particle contamination data obtained during the testing program. These patches may be used as future standards if a patch test is adopted for armored vehicles.

The patches show a rough correlation between the weight of gravimetric insoluble material, the automatic particle count, and the Navy patch class. Appendix I lists the patch test correlation data. Since most of the Fort Sill samples failed the Navy patch test, which has a maximum rating of 6, additional patch ratings of 7, 8, and 9 were assigned to describe many of the Fort Sill samples, which were darker shades of grey to black. This was done to determine if the patch colors correlated with the quantity of contamination. A graph of gravimetric insolubles versus the "Extended" Navy Patch Kit Ratings is shown in Appendix J. A difficulty using the patch test at high contamination levels was that there was less color difference between samples than at the lower contamination levels so that discrimination between different levels of cleanliness was more difficult, if not impossible.

However, this method, with appropriate color standards for ground vehicles, would be useful for self-propelled artillery if improved filtration is used on each vehicle so that the hydraulic fluids become much cleaner. With the installation of new and improved filtration units on each vehicle, an increased awareness of hydraulic fluid cleanliness would be required. At that time, a method of monitoring hydraulic fluid cleanliness would be desirable and the patch test method is a good candidate.

Section VI
Conclusions and Recommendations

No hydraulic fluid deterioration trends can be confirmed at this time, approximately halfway through the anticipated testing program. It is recommended that this program continue until all original samples have reached a 36-month age. Additional acid number and 4 Ball Wear Test data will be very informative.

All fluid samples were quite dirty and most contained too much water. Improved techniques and/or equipment modifications are needed to eliminate this problem. Fluid cleanliness and water control can be achieved in many ways. Improved filtration is recommended to remove the solid contaminants. Care must be taken in filling and replenishing hydraulic systems to avoid introducing contamination into the system. Opened hydraulic fluid cans and leftover fluid must be discarded since the fluid becomes contaminated when the container is opened. Use of a portable fluid purifier unit can be a useful maintenance procedure. Redesign to include a closed hydraulic system would provide significant cleanliness and water improvements. Also, reservoir purifier/breathers can prevent some moisture and contaminants from entering the system. A significant improvement in the cleanliness of the hydraulic fluid would prevent unnecessary fluid changes and thus reduce costs of fluid replacement and disposal.

References

1. Militrry Specification MIL-H-6083E, *Hydraulic Fluid, Petroleum Base, for Preservation and Operation*, 14 August 1986.

2. Military Specification MIL-H-46170B, *Hydraulic Fluid, Rust Inhibited, Fire Resistant, Synthetic Hydrocarbon Base*, 18 August 1982.

3. Military Standard MIL-STD-1246B, *Product Cleanliness Levels and Contamination Control Program*, 4 September 1987.

4. Technical Manual NAVAIR 01-1A-17, *Aviation Hydraulics Manual, Organizational, Intermediate and Depot Maintenance*, 15 August 1989.

5. Technical Manual NAVAIR 17-15E-52, *Hydraulic Fluid Contamination Analysis Kit*, 1 March 1981.

Appendix A
In-Service Use Limits for MIL-H-6083 Used in Self-Propelled Artillery—Test Plan

PURPOSE

To develop meaningful in-service use limits and assist in establishing a standard drain/replacement procedure for MIL-H-6083 (OHT) hydraulic fluid being used in self-propelled artillery.

SCOPE

OHT samples are to be drawn at regular intervals from the hydraulic fluid systems of M109 and M110 Self-Propelled Artillery located at the III Corps Artillery, Fort Sill, OK. The samples will be analyzed at this laboratory for water content, total acid number, corrosion protection, particulate contamination, viscosity, and other tests deemed appropriate. The laboratory results will be correlated with those data obtained through the Army Oil Analysis Program (AOAP) and the vehicle log data, such as accumulated mileage between sampling, hours of operation, number of firings, etc., to determine OHT in-service use limits for these vehicles.

POINTS OF CONTACT

Fort Sill is willing to support the OHT in-service use limits testing.
Points of contact are:

1. Lt. Col. St. Cyr	DSN 639-4962, 639-6509
2. Capt. Taylor	DSN 639-4962, 639-6485
3. MSgt. Tronson	DSN 639-4962, 639-6485

Headquarters, III Corps Artillery
ATTN: AFVI-HD
Fort Sill, OK 73503

The US Army Belvoir Research, Development and Engineering Center (BRDEC) has overall program responsibility. Point of contact is Ms. Connie Van Brocklin, Materials, Fuels and Lubricants Laboratory, Fuels and Lubricants Division, Fort Belvoir, VA 22060-5606, Telephone: DSN 354-4594, Commercial (703) 664-4594.

RESPONSIBILITIES

Fort Sill:

- Identify M109 and M110 vehicles that will be dedicated for this project.
- Draw OHT samples according to agreed- upon procedures, provide vehicle information, and send the samples and vehicle information sheets to BRDEC. Concurrent with the sampling, submit an additional sample to the AOAP laboratory and provide a copy of their results to BRDEC.

BRDEC:

- Provide sampling instructions, sample containers, vehicle information sheets, and shipping containers for Fort Sill.
- Analyze OHT samples in the laboratory.
- Develop OHT in-service use limits and disseminate results.

PERIOD OF TEST

Sampling of hydraulic fluid, at intervals of approximately 6 months, will commence as soon as possible, and continue until samples representing usage periods from 0 months to 3 years or longer have been acquired from selected vehicles. If some of the selected vehicles have not had a hydraulic fluid replacement for 2 years or more, and if their present maintenance records contain data such as date of fluid change, hours of operation or accrued mileage, and number of firings since the last fluid change, it is anticipated that this project could be completed within a period of approximately 1 year. If such data do not exist, the project will be required to continue until the fluids show evidence that their continued use could prove detrimental to the hydraulic fluid and gun control systems. However, it is anticipated that this testing program should not exceed 2 years.

DETAILED TEST PROCEDURES

1. Selection of Test Vehicles and Sampling Interval

The success of this project depends upon accurate hydraulic fluid data from the maintenance records of each vehicle accompanying each sample. The maintenance records of the vehicles to be selected for this program must contain the date of last hydraulic fluid replacement (and the basis for this change) and supporting information concerning mileage, hours of operation, and number of firings (to correlate the effects of firing to the life of the hydraulic fluid). The only useful information will be acquired from sampling the same fluid from the same vehicle over time. It is proposed that sets of four vehicles (i.e., two M109s, two M110s) be selected for sampling which meet each of the following conditions:

- M109 and M110 vehicles having had their OHT changed recently (i.e., representing new or extremely low use conditions).
- M109 and M110 vehicles having their OHT in use for approximately 1 year without being changed.
- M109 and M110 vehicles having their OHT in use for approximately 2 years without being changed.
- M109 and M110 vehicles having their OHT in use for approximately 3 years without being changed.

This test set will comprise a total of 16 vehicles—eight M109s and eight M110s. When selecting the 16 vehicles, every attempt should be made to match the vehicles as closely as possible to each other within each of the four OHT "use" conditions. Once selected, these vehicles should not be subjected to the "prevailing" drain/replacement interval for OHT unless absolutely necessary since any vehicle changes will affect data collection and subsequently introduce variables that we cannot account for.

Draw initial fluid samples from each of the "selected" vehicles. Samples are then to be obtained at 6-month intervals. It is anticipated that this sampling will provide sufficient data to establish meaningful in-service use limits for OHT.

Additionally, valuable information will be derived from this analysis of hydraulic fluids should any vehicles experience a hydraulic fluid related problem as this information will be made available.

2. Hydraulic Fluid Sampling Procedure

Standard AOAP sampling techniques should be followed. However, the standard AOAP sample is 3 ounces and the samples required for BRDEC testing are 1 quart.

In order to obtain samples representative of the total contents of each hydraulic system, certain sampling procedures have to be followed.

- Determine the most representative hydraulic fluid sampling point(s) in each vehicle to be used for this project, i.e., the sampling points used for drawing hydraulic fluid samples for AOAP analysis.

- Subject the hydraulic system to an exercising/circulating period to insure that the fluid in the system is well mixed and the sample to be obtained is representative. Ideally, this exercising period should be one during which the OHT is allowed to reach its normal operating temperature.

- Rinse a clean, 1-quart sample container with some hydraulic fluid drawn from the predetermined sampling point. Then completely fill the container and identify with a stick-on label containing vehicle serial number and sampling date. An additional, separate form is required for each sample which will contain more detailed data from the vehicle log book. A copy of the form showing the data needed is provided as Attachment A.

- Immediately following this sampling, withdraw a standard 3-ounce sample of hydraulic fluid and submit to the AOAP laboratory for testing using the normal procedures specified. When this AOAP testing is completed, send a copy of the AOAP results to BRDEC.

  If the withdrawal of these samples has lowered the amount of fluid within the vehicle's reservoir to below the designated "Full" mark, add the required amount of new OHT. Record the amount of OHT added, and any other subsequent additions of fluid during the testing period.

- Forward samples to the following address:

  Commander
  US Army Belvoir Research, Development and Engineering Center
  ATTN: STRBE-VF (Ms. Van Brocklin)
  Fort Belvoir, VA 22060-5606

3. Laboratory Testing

The following laboratory tests will be performed at BRDEC's Materials, Fuels, and Lubricants Laboratory.

Test	Test Method
% water	ASTM D1744
Total acid number	ASTM D664
Viscosity, cSt at 40°C	ASTM D445
Solid particle contamination, gravimetric method	ASTM F313
Particle size distribution (Note: performed only when gravimetric method indicates the sample is "clean" enough)	Hiac Automatic Particle Counter
Galvanic corrosion*	FTM 5322
Corrosion rate evaluation procedure*	—
Steel-on-steel wear (Note: performed only on 2 to 3 year old samples)	ASTM D4172
Chlorine contamination	—

*This test will not be performed routinely, but only when supported by other test data.

DEFINITIONS

Specification Limits: The physical and chemical requirements which a product must fully meet to be qualified and accepted at time of procurement. These limits are always cited in every product specification as they prescribe the performance capabilities which manufacturers/suppliers must comply with.

Deterioration Limits: The extent that properties of an unused product may deteriorate beyond specification requirements during storage or handling, without rendering the product unusable. Deterioration limits are described in tolerances established by MIL-HDBK-200G which permit use, under certain conditions, of products that do not fully meet specifications. Deterioration limits are often referred to as "use limits."

In-Service Use Limits: The extent to which physical and chemical properties of a product may deteriorate while in use without adversely affecting the performance capabilities of that product. These in-service use limits will normally exceed the established deterioration/use limits as they take into account environmental contamination, system effects, additive depletion, and wear-generated debris. These in-service use limits are established after laboratory testing has been correlated with field exercises knowing the full limitations of performance with those products in question.

VEHICLE LOG DATA TO ACCOMPANY EACH HYDRAULIC FLUID SAMPLE

Vehicle Serial Number: ______________________________

Vehicle Type: ______________________________

Sampling Point: ______________________________

Date sampled: ______________________________

Date of previous sampling: ______________________________

Date of last hydraulic fluid change: ______________________________

Date of last hydraulic fluid filtering ("recycling"): ______________________________

Source/name of fluid filtering ("recycling") process, if known: ______________________________

____

Date of last hydraulic fluid filter replacement, if applicable: ______________________________

____

Hydraulic fluid added since last sampling:

Date	Amount of OHT added	Reason

Odometer reading: ______________________________

Odometer reading since last fluid change: ______________________________

Total hours of service: ______________________________

Hours of service since last fluid change: ______________________________

Total number of shots fired or equivalent: ______________________________

Number of shots fired or equivalent since last fluid change: ______________________________

Point of contact: ______________________________

Please enclose the AOAP report for this sample.

Attachment A

Appendix B
Vehicle Log Data/Hydraulic Fluid Age for Each Participating Vehicle

Page No. 1
09/10/90

Vehicle Log Data/Hydraulic Fluid Age
for Each Participating Vehicle

Vehicle Number	Other Name	Vehicle Type	Battalion	Sample Date	Fluid Age	% Fluid Added	Odometer Reading	Miles Since Change	[illegible]	[illegible]
171		M109A3	1/17	08-19-88	07 month		00354	00294	[illegible]	[illegible]
171		M109A3	1/17	03-17-89	14 month		00393	00333	[illegible]	[illegible]
171		M109A3	3/18	04-23-90	25 month		03224	unk	00530	00184
PCF184		M110A2	2/18	09-23-88	00+month		02036	unk	00220	00220
PCF184		M110A2	2/18	03-08-89	07+month		02587	unk	00297	00297
PCF 184		M110A2	2/18	10-05-89	14+month		02853	unk	00328	unk
PCF 184	C-11	M110A2	2/18	04-11-90	05 month		03313	00426	00378	00044
241		M109A3	2/34	08-18-88	04 month		00378	unk	00038	00038
241		M109A3	2/34	03-00-89	11 month		00911	unk	unk	unk
FMC288		M110A2	5/18	08-18-88	12 month		02040	02040	00204	00204
FMC288		M110A2	5/18	03-02-89	19 month		02500	02500	00250	00250
FMC288		M110A2	5/18	11-21-89	27 month	7	02970	02970	00297	00297
FMC 288	A-74	M110A2	6/18	04-11-90	32 month	18	02028	03343	00344	unk
[illegible]		M109A3	3/18	08-18-88	06 month		00905	unk	00127	00056
356		M109A3	3/18	03-03-89	13 month		01212	unk	00188	00087
356		M109A3	3/18	10-16-89	20 month	11	01546	unk	00404	00332
356	C-12	M109A3	3/18	04-19-90	26 month		01546	unk	00404	unk
BMY434		M110A2	6/18	08-22-88	02 month		00065	00066	00004	00004
BMY 434		M110A2	6/18	03-02-88	09 month		00423	00423	00047	00047
BMY 434		M110A2	5/18	11-21-89	17 month	5	01130	01130	00113	00113
BM 434	B-88	M110A2	5/18	04-11-90	22 month		00317	01537	00182	00162
BMY501		M110A2	2/18	09-23-88	01 month		00077	00077	00008	00009
BMY501		M110A2	2/18	03-01-89	06 month	1	00898	00283	00082	00054
BMY 501		M110A2	2/18	10-05-89	14 month		01388	01388	00128	00128
BMY501	A-12	M110A2	2/18	04-12-90	04 month		01798	unk	00192	00038

Vehicle Log Data/Hydraulic Fluid Age
for Each Participating Vehicle

Vehicle Number	Other Name	Vehicle Type	Battalion	Sample Date	Fluid Age	% Fluid Added	Odometer Reading	Miles Since Change	Hours of Service	Hours Since Change
BMY619		M110A2	2/18	08-23-88	01 month		00143	00143	00014	00014
BMY619		M110A2	2/18	03-02-89	08 month		00771	00771	0	00080
BMY 619		M110A2	2/18	10-05-89	03 month		00795	00020	00278	00002
BMY 619	B-14	M110A2	2/18	04-11-90	07 month		00771	unk	00200	unk
BMY728		M110A2	5/18	08-17-88	07 month		00811	00811	00063	00063
BMY728		M110A2	5/18	03-02-89	14 month		00956	00958	00097	00097
BMY 728		M110A2	5/18	11-21-89	22 month	11	00143	00143	00159	00159
BMY 728	C-78	M110A2	5/18	04-11-90	27 month		04030	04030	00403	00403
1199		M109A3	1/17	08-19-88	02 month		unk	unk	00094	00009
1199		M109A3	1/17	03-17-89	09 month		01095	00980	00200	00115
1199		M109A3	1/17	09-23-89	16 month		02482	unk	00284	00179
1199	A-15	M109A3	1/17	05-16-90	23 month		01390	01390	unk	unk
1314		M109A3	3/18	8-18-88	00-month		00555	unk	00058	00048
1314		M109A3	3/18	03-03-89	00 month		00805	00340	00087	00004
1314		M109A3	3/18	10-16-89	07 month		01108	00343	00167	00074
1314		M109A4	3/18	04-19-90	03 month		01503	00246	00834	00087
1439		M109A3	2/34	08-18-88	00-month	80	03705	unk	00668	00668
1439		M109A3	2/34	03-00-89	07-month		06638	unk	unk	unk
1439		M109A3	1/17	09-29-89	13-month		unk	unk	00719	00719
1672		M109A3	3/18	08-18-88	07 month		05575	unk	00739	00110
1672		M109A3	3/18	03-03-89	14 month	20	05875	unk	00792	00163
1872		M109A3	3/18	10-11-89	21 month		06052	unk	00824	00195
1672		M109A4	3/18	04-19-90	33 month		06376	00320	00824	00047
1791		M109A3	2/34	08-18-88	00-month		06403	unk	00874	00874
1791		M109A3	2/34	03-00-89	07-month		06558	unk	unk	unk

Vehicle Log Data/Hydraulic Fluid Age
for Each Participating Vehicle

Vehicle Number	Other Name	Vehicle Type	Battalion	Sample Date	Fluid Age	% Fluid Added	Odometer Reading	Miles Since Change	Hours of Service	Hours Since Change
1824		M109A3	1/17	08-19-88	00+month	42	unk	unk	00821	unk
1924		M109A3	1/17	03-02-89	07+month		04922	unk	00871	unk
1824		M109A3	1/17	09-27-89	13+month		04337	unk	00716	unk
1824	B-13	M109A3	1/17	05-17-90	20+month		35629	unk	unk	unk
1839		M109A3	2/34	08-18-88	00+month		00385	unk	00035	unk
1839		M109A3	1/17	03-00-89	07+month		00894	unk	unk	unk
1839		M109A3	1/17	09-25-89	13+month		00650	unk	00075	unk
1839	A-12	M109A3	1/17	05-16-90	20+month		03150	03150	unk	unk
2607	B-12	M109A3	1/17	05-17-90	09 month		02821	02821	unk	unk
12033468	B-12	M109A3	1/17	09-27-89	01 month		02098	00100	00178	00010
12033468	B-12	M109A3	1/17	03-02-89	16 month		01495	unk	00131	00131
12033468	B-12	M109A3	1/17	06-19-88	09 month	16	unk	unk	00088	00088

Appendix C
Particle Contamination Standards

(Based on 100 ml Samples)

NAVAIR 01-1A-17

Particle Contamination Level—By Class

Micron Size Range	Acceptable 0	1	2	3	4	Unacceptable 5	6
5-10	2,700	4,600	9,700	24,000	32,000	87,000	128,000
10-25	670	1,340	2,680	5,360	10,700	21,400	42,000
25-50	93	210	380	780	1,510	3,130	6,500
50-100	16	28	56	110	225	430	1,000
Over 100	1	3	5	11	21	41	92
Total	3,480	6,181	12,821	30,261	44,456	112,001	177,592

Typically and approximately

Class 0 = Fluid specification
Class 1 = Ultraclean system
Class 2 = Good missile system
Class 3 = Critical systems in general
Class 4 = Critical systems, in general
Class 5 = Poor missile system
Class 6 = Industrial service

MIL-STD-1246B, Level 200

Particle Size Range (Microns)	Number Particles
Over 15	4,190
Over 25	1,240
Over 50	170
Over 100	16

Army MERADCOM (BRDEC) Standard for Construction, Earth Moving, and Material Handing Equipment

Particle Size Range (Microns)	Number Particles
Over 10	100,000
Over 20	1,000

NAS 1638
January 1964, Aerospace Industries Association of America, Inc.

Particle Size Range (Microns)	Per Class 00	0	1	2	3	4	5	6	7	8	9	10	11	12
5-15	125	250	500	1,000	2,000	4,000	8,000	16,000	32,000	64,000	128,000	256,000	512,000	1,024,000
15-25	22	44	89	178	356	712	1,425	2,850	5,700	11,400	22,800	45,600	91,200	182,400
25-50	4	8	16	32	63	126	253	506	1,012	2,025	4,050	8,100	16,200	32,400
50-100	1	2	3	6	11	22	45	90	180	360	720	1,440	2,880	5,760
Over 100	0	0	1	1	2	4	8	16	32	64	128	256	512	1,024

Appendix D
Typical Values and Specification Limits of Some Physical Properties of MIL-H-6083 Hydraulic Fluids

Physical Property	Test Method	Specification Limit	Typical Value (New Fluid)
Viscosity, 40°C, cSt	ASTM D445	13.0, min	13.7
Acid number, mgKOH/g	ASTM D664	0.20	0.08
Water, percent	ASTM D1744	0.05, max	0.014
Gravimetric insolubles, mg/100 ml	ASTM F313	0.5, max	0.00
Particle size, # particles each size, microns, max	Automatic Particle Counter		
5-25		10,000	2,000
26-50		250	50
51-100		50	10
over 100		10	0
4 Ball Wear, scar diam., mm	ASTM D4172	1.00, max	0.780
Galvanic Corrosion (Corrosivity)	FED-STD-791 Method 5322	pass	pass

Appendix E
Laboratory Data for Used Hydraulic Fluid

Page No. 1
09/10/90

Laboratory Data for Used Hydraulic Fluid

Vehicle Number	Sample Date	Fluid Age	Miles Since Change	Hours Since Change	Percent Water	Acid No.	Visc. @ 40 Deg C	Grav. Insol. (mg)	Part. Count 5-25 Micron	Part. Count 26-50 Micron	Part. Count 51-100 Micron	Part. Count > 100 Micron	Galvan. Corr.	4 Ball Wear (40 kg,
171	08-19-88	07 month	00294	00030	0.092	0 314	13.5	8.28	861,710	480	10	0		0.609
171	03-17-89	14 month	00333	00067	0.070	0.212	13.8	1.96	418,770	2,450	110	0		
171	04-23-90	26 month	unk	00154	0.07		12.9	2.04	930,270	4,300	820	20		
PCF184	09-23-88	00+month	unk	00229	0.098	0.127	13.5	3.44	298,500	1,460	190	0	pass	0.591
PCF184	03-08-89	07+month	unk	00297	0.089	0.104	13.8	8.49	136,790	25,540	3,800	160		
PCF 184	10-05-89	14+month	unk	unk	0.038		13.2	1.87						
PCF 184	04-11-90	05 month	00426	00044	0.21		13.4		32,370	56,070	65,960	xxx		
241	08-18-88	04 month	unk	00038	0.096	0.262	14.5	12.48	303,600	2,400	170	0		0.701
241	03-00-89	11 month	unk	unk	0.073	0.144	13.9	0.88	458,280	2,850	39.	10		
FMC286	08-18-88	12 month	02040	00204	0.084	0.258	13.4	3.20	1,517,030	5,120	280	0		0.623
FMC286	03-02-89	19 month	02500	00250	0.113	0.118	13.4	2.16	237,080	2,630	210	0		0.884
FMC286	11-21-89	27 month	02970	00297	0.020		13.3	2.06						1 362
FMC 286	04-11-90	32 month	03343	unk	0.13		13.6	13.58	212,680	29,320	2,780	400		0.348
356	08-18-88	06 month	unk	00058	0.081	0.267	13.7	5.56	1,420,130	1,860	80	0		0.643
356	03-03-89	13 month	unk	00097	0.074	0.208	13.7	1.03	312,130	2,410	100	0		0.971
356	10-19-89	20 month	unk	00332	0.037		13.9	0.51						0.665
356	04-19-90	28 month	unk	unk	0.06		13.8	1.76	1,863,810	2,420	170	0		0.968
BMY434	08-22-88	02 month	00086	00004	0.023	0.164	13.1	6.18	860,050	20,240	30	0		0.858
BMY 434	03-02-88	09 month	00423	00047	0.047	0.098	13.2	2.56	178,278	21,830	1,240	40		
BMY 434	11-21-89	17 month	01120	00113	0.023		13.3	2.23						
BM 434	04-11-90	22 month	01837	00182	0.07		13.5	2.12	1,065,970	8,180	630	20		
BMY501	09-23-88	01 month	00077	00009	0.098	0.147	13.5	3.78	422,420	25,420	810	2		0.612
BMY501	03-01-89	06 month	00283	00054	0.089	0.127	13.4	3.53	240,820	8,810	1,010	10		
BMY 501	10-05-89	14 month	01388	00128	0.042		13.2	1.35						
BMY501	04-12-90	04 month	unk	00028	0.07		12.9	1.68	1,277,580	3,750	230	0		

Laboratory Data for Used Hydraulic Fluid

Vehicle Number	Sample Date	Fluid Age	Miles Since Change	Hours Since Change	Percent Water	Acid No.	Visc. @ 40 Deg C	Grav. Insol. (mg)	Part. Count 5-25 Micron	Part. Count 26-50 Micron	Part. Count 51-100 Micron	Part. Count > 100 Micron	Galvan. Corr.	4 Ba. Wear (40 kg).
SMY6:9	03-23-88	01 month	00143	00014	0.042	0.126	13.3	4.48	292,560	1,280	140	0		0.672
SMY619	03-02-89	08 month	00771	00080	0.068	0.124	13.3	2.68	261,440	2,470	220	10		
SMY 619	10-05-89	03 month	00020	00002	0.017		13.4	0.74						
SMY 619	04-11-90	07 month	unk	unk	0.09		13.5	1.12	1,481,510	2,320	280	0		
SMY726	08-17-88	07 month	00811	00053	0.076	0.191	13.5	3.09	9,207,210	28,170	270	10		0.646
SMY726	03-02-89	14 month	00958	00097	0.268	0.130	13.2	1.93	261,160	3,730	60	10		0.742
SMY 726	11-21-89	22 month	00143	00158	0.084		13.1	1.67						0.595
SMY 726	04-11-90	27 month	04030	00403	0.21		13.4	5.38	1,874,000	4,740	420	0		0.853
1199	08-19-88	02 month	unk	00009	0.060	0.243	13.1	3.52	1,248,580	900	80	0		0.586
1199	03-17-89	09 month	00980	00115	0.046	0.153	13.5	0.74	180,810	27,150	420	10		
1199	09-25-89	16 month	unk	00179	0.030		13.7	0.89						
1199	05-16-90	23 month	01390	unk	0.10		13.0	2.16						
1314	8-18-88	00+month	unk	00048	0.097	0.274	13.5	1.86	111,400	4,260	70	0		0.312
1314	03-03-89	00 month	00040	00004	0.085	0.210	13.8	0.19	657,110	1,890	150	10		
1314	10-16-89	07 month	00373	00074	0.016		13.6	0.85						
1314	04-19-90	03 month	00248	00087	0.10		13.7	4.0	56,990	6,010	1,290	150		
1439	08-18-88	00+month	unk	00686	0.076	0.258	13.6	7.30	485,610	2,450	190	10		0.610
1439	03-00-89	07+month	unk	unk	0.028	0.130	13.8	1.58	630,130	790	80	0		
1439	09-29-89	13+month	unk	00719	0.018		13.4	0.23						
1672	08-18-88	07 month	unk	00110	0.131	0.245	14.1	8.04	1,749,190	3,470	80	0	pass	0.822
1672	03-03-89	14 month	unk	00163	0.098	0.130	13.7	2.35	270,090	1,170	160	0		
1672	10-11-89	21 month	unk	00196	0.026		14.0	0.90						0.833
1672	04-19-90	03 month	00223	00047	0.04		13.8	1.50	601,760	7,840	1,220	40		0.831
1791	08-18-88	00+month	unk	00674	0.103	0.176	14.2	5.76	366,440	1,370	310	10	pass	0.840
1791	03-00-89	07+month	unk	unk	0.091	0.164	13.7	1.74	313,730	2,910	120	0		0.882

Laboratory Data for Used Hydraulic Fluid

Vehicle Number	Sample Date	Fluid Age	Miles Since Change	Hours Since Change	Percent Water	Acid No.	Visc. @ 40 Deg C	Grav. Insol. (mg)	Part. Count 5-25 Micron	Part. Count 26-50 Micron	Part. Count 51-100 Micron	Part. Count > 100 Micron	Galvan. Corr.	4 Ba Wear (40 kg)
1824	08-19-88	00+month	unk	unk	0.087	0.235	13.7	4.38	1,564,780	1,510	120	0	pass	0.823
1824	03-02-89	07+month	unk	unk	0.171	0.124	13.7	1.59	276,320	5,750	410	0		
1824	09-27-89	13+month	unk	unk	0.051		13.6	2.09						
1824	05-17-90	20+month	unk	unk	0.14		13.9	4.26						
1839	08-18-88	00+month	unk	unk	0.081	0.291	13.7	2.74	626,400	890	100	0	pass	0.72:
1839	03-00-89	07+month	unk	unk	0.098	0.277	13.9	0.42	533,600	1,160	120	0		
1839	09-25-89	13+month	unk	unk	0.044		13.3	0.87						
1839	05-16-90	20+month	03150	unk	0.12		13.6	3.10						
2607	05-17-90	09 month	02821	unk	0.12		13.5							
12033468	09-27-89	01 month	00100	00010	0.027		13.8	1.21						
12033468	03-02-89	16 month	unk	00131	0.242	0.251	13.9	1.66	334,460	9,200	430	10		
12033468	08-19-88	09 month	unk	00088	0.050	0.280	13.0	11.42	1,708,750	2,080	40	0		0.791

Appendix F
Data on OHT Samples by Fluid Age

Page No.
09/10/90

Data on OHT Samples by Fluid Age

Serial #	Change Date	Fluid Age	Mileage	Engine Hours	% Water	Acid #	Visc	Grav.	Galvanic Corrosion	4 Ball Wear Test
1314	02-22-89	00 month	00805	00087	0.085	0.210	13.6	0.19		
PCF184	unk	00+month	02036	00229	0.098	0.127	13.5	3.44	pass	0.591
1314	unk	00+month	00555	00058	0.097	0.274	13.5	1.86		0.812
1439	unk	00+month	03705	00666	0.076	0.258	13.6	7.30		0.610
1791	unk	00+month	06403	00674	0.103	0.176	14.2	5.76	pass	0.840
1824	unk	00+month	unk	00621	0.087	0.235	13.7	4.38	pass	0.823
1839	unk	00+month	00385	00035	0.081	0.291	13.7	2.74	pass	0.721
BMY501	08-00-88	01 month	00077	00009	0.098	0.147	13.6	3.78		0.612
BMY619	09-02-88	01 month	00143	00014	0.042	0.126	13.3	4.48		0.672
12033468	08-01-89	01 month	02098	00176	0.027		13.8	1.21		
BMY434	08-00-88	02 month	00065	00004	0.033	0.164	13.1	5.18		0.668
1199	06-03-88	02 month	unk	00094	0.068	0.243	13.1	3.52		0.586
BMY 619	07-06-89	03 month	00795	00278	0.017		13.4	0.74		
1314	01-90	03 month	01503	00834	0.10		13.7	4.0		
1672	01-90	03 month	06376	00824	0.04		13.8	1.50		0.931
241	04-00-88	04 month	00376	00038	0.096	0.262	14.5	12.48		0.701
BMY501	12-11-89	04 month	01798	00192	0.07		12.9	1.68		
PCF 184	11-07-89	05 month	03313	00376	0.21		13.4			
BMY501	10-00-88	05 month	00898	00082	0.089	0.127	13.4	3.53		
356	02-00-88	06 month	00905	00127	0.081	0.287	13.7	5.58		0.643
171	01-15-88	07 month	00354	00704	0.092	0.314	13.5	6.28		0.609
BMY 619	08-11-89	07 month	00771	00208	0.09		13.6	1.12		
BMY726	01-00-88	07 month	00811	00053	0.078	0.191	13.6	3.09		0.646
1314	03-89	07 month	01108	00157	0.016		13.6	0.86		
1672	01-11-88	07 month	06575	00739	0.131	0.245	14.1	8.04	pass	0.822
PCF184		07+month	02597	00297	0.089	0.104	13.8	8.49		

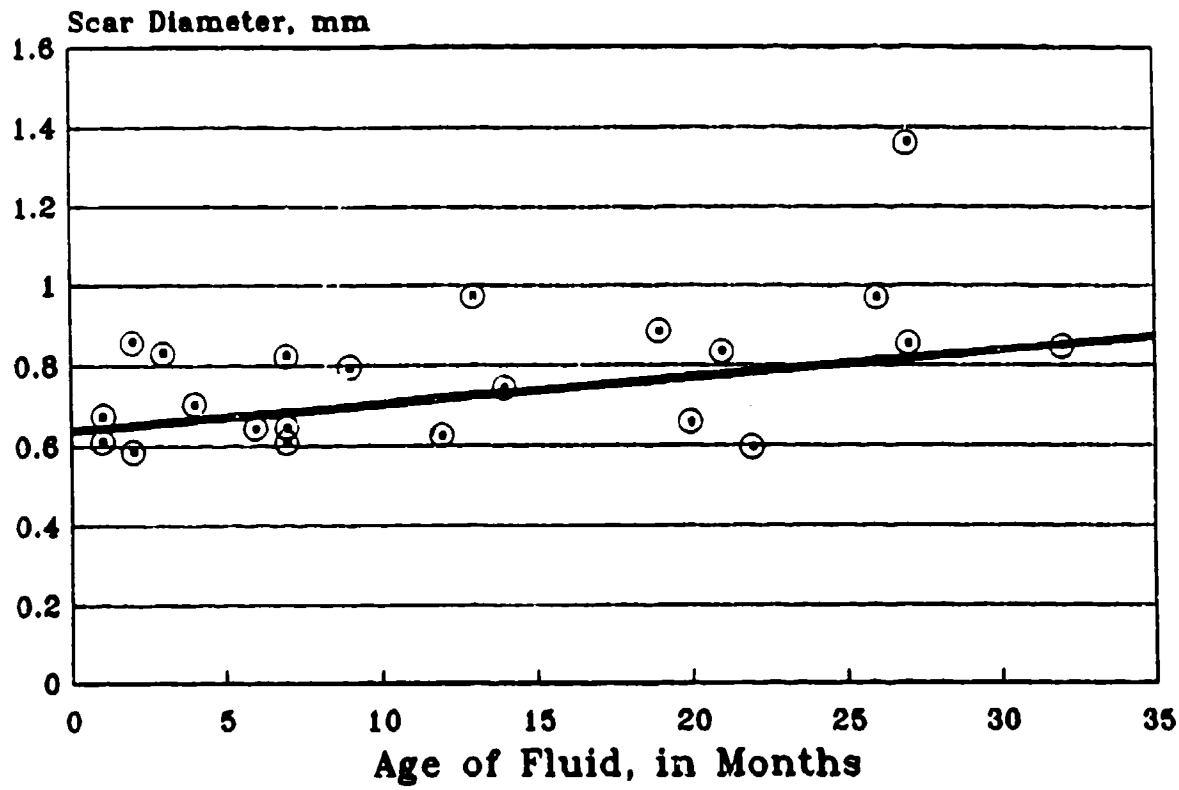
Data on OHT Samples by Fluid Age

Serial #	Change Date	Fluid Age	Mileage	Engine Hours	% Water	Acid #	Visc	Grav.	Galvanic Corrosion	4 Ball Wear Test
1439	unk	07+month	06638	unk	0.028	0.130	13.8	1.58		
1791	unk	07+month	06558	unk	0.081	0.164	13.7	1.74		0.862
1824	unk	07+month	04922	00671	0.171	0.124	13.7	1.59		
1839	unk	07+month	00894	unk	0.098	0.277	13.9	0.42		
BMY619	08-00-88	08 month	00771	00080	0.068	0.124	13.3	2.68		
SMY 434	06-00-88	09 month	00423	00047	0.047	0.098	13.2	2.56		
1199	06-00-88	09 month	01095	00200	0.046	0.153	13.5	0.74		
2607	08-01-89	09 month	02821	unk	0.12		13.5			
12D33468	11-09-87	09 month	unk	00088	0.050	0.280	13.0	11.42		0.791
241	04-00-88	11 month	00911	unk	0.073	0.144	13.9	0.86		
FMC286	08-00-87	12 month	02040	00204	0.094	0.258	13.4	3.20		0.623
356	02-00-88	13 month	01212	00169	0.074	0.208	13.7	1.03		0.971
1439	unk	13+month	unk	00719	0.018		13.4	0.23		
1824	unk	13+month	04937	00716	0.051		13.6	2.09		
1939	unk	13+month	00650	00075	0.044		13.3	0.87		
171	01-15-88	14 month	00393	00741	0.070	0.212	13.8	1.96		
SMY 501	08-88	14 month	01386	00128	0.042		13.2	1.35		
SMY726	01-00-88	14 month	00956	00097	0.266	0.130	13.2	1.93		0.742
1672	01-11-88	14 month	05875	00792	0.088	0.130	13.7	2.36		
PCF 184	unk	14+month	02853	00326	0.038		13.2	1.87		
1199	06-88	16 month	02482	00264	0.030		13.7	0.89		
12D33468	12-00-87	16 month	01465	00131	0.242	0.251	13.9	1.66		
BMY 434	06-88	17 month	01130	00113	0.022		13.3	2.23		
FMC286	08-00-87	19 month	02500	00250	0.113	0.118	13.4	2.15		0.884
356	02-88	20 month	01545	00404	0.037		13.9	0.51		0.655
1824	unk	20+month	05829	unk	0.14		13.9	4.28		

Data on OHT Samples by Fluid Age

Serial #	Change Date	Fluid Age	Mileage	Engine Hours	% Water	Acid #	Visc	Grav.	Galvanic Corrosion	4 Ball Wear Test
1839	unk	20+month	03150	unk	0.12		13.6	3.10		
1672	01-88	21 month	06052	00824	0.026		14.0	0.90		0.833
BM 434	6-88	22 month	00317	00182	0.07		13.5	2.12		
BMY 726	01-88	22 month	00143	00169	0.084		13.1	1.87		0.595
1195	06-88	23 month	01390	unk	0.10		13.0	2.16		
171	unk	25 month	03224	00530	0.07		12.9	2.04		
356	02-88	26 month	01545	00404	0.05		13.8	1.76		0.968
FMC286	08-87	27 month	02970	00297	0.039		13.3	2.05		1.362
BMY 726	01-88	27 month	04030	00403	0.21		13.4	5.38		0.853
FMC 286	8-87	32 month	02039	00344	0.13		13.6	13.58		0.848

Appendix G
4 Ball Wear Test Data



Appendix H
AOAP Data From Ft. Sill Samples

AOAP Data from Ft. Sill Samples

Vehicle	Date	Since Ovhl	Since Change	Odom Read	Vis	H20	FE	AG	AL	CR	CU	MG	TI	PB	SN	NI	MO	Si	NA	ZN	B
171	5-20-88	-	-	342	018	pass	005	000	007	003	013	003	002	010	000	002	003	016	017	014	003
PCF184	10-12-88	246	246	2237	018	fail	006	000	008	002	002	001	000	001	000	000	000	060	017	[illegible]	[illegible]
PCF184	4-17-89	301	301	-	20	fail	014	000	009	002	004	003	000	004	000	000	000	064	014	007	000
PCF184	10-13-89	328	328	2887	19	fail	002	000	001	001	003	000	000	001	000	001	001	056	015	005	000
241	6-10-88	14	14	-	017	pass	004	000	006	003	003	004	000	005	000	003	000	005	017	002	003
FMC286	03-02-89	-	-	1278	020	pass	002	000	009	002	002	000	000	004	000	001	001	044	018	006	000
FMC286	3-22-89	-	-	1356	18	pass	011	000	008	003	002	000	000	004	000	000	000	053	017	006	000
356	1-27-88	49	49	-	018	pass	005	000	011	003	006	004	000	009	000	000	000	414	021	039	002
356	2-11-88	71	0	-	019	pass	005	000	006	003	006	003	000	010	000	000	000	069	019	026	003
356	8-18-88	127	56	-	017	pass	005	000	006	003	007	003	000	010	000	000	000	069	019	026	003
356	12-29-88	142	71	998	019	pass	002	000	003	001	005	001	000	009	000	000	000	058	027	023	000
356	3-3-89	168	35	-	18	pass	004	000	003	002	004	001	000	007	000	001	000	050	029	016	000
356	10-16-89	404	333	1545	20	pass	002	000	000	001	005	001	000	004	000	000	000	039	038	014	007
BMY434	3-2-89	-	-	423	019	pass	001	000	008	001	002	000	000	003	000	001	000	208	014	012	000
BMY501	8-15-88	77	9	-	019	pass	002	000	004	001	000	001	000	001	000	000	000	064	020	006	000
BMY501	10-17-89	134	6	-	20	fail	003	000	006	000	001	001	000	002	000	000	000	149	017	011	000
BMY501	11-21-89	141	2	-	20	fail	004	000	008	001	002	002	000	004	001	000	000	233	020	015	001
BMY501	12-11-89	156	2	1658	19	pass	001	000	001	000	000	000	000	000	002	000	001	001	015	001	000
BMY619	8-1-88	11	11	-	017	pass	004	000	007	003	004	000	000	006	000	002	004	137	016	009	003
BMY619	8-15-89	126	117	-	18	pass	005	000	005	001	008	001	000	005	001	000	001	298	018	020	001
BMY619	08-24-89	127	118	771	16	fail	005	000	005	001	005	001	000	005	000	000	001	252	019	016	000
BMY619	8-24-89	127	0	-	18	pass	000	000	007	000	000	000	000	000	000	000	000	008	010	001	000
BMY726	3-3-89	97	97	956	019	pass	002	000	007	001	001	001	000	002	000	000	000	116	020	009	000
1199	6-3-88	190	190	887	018	pass	003	000	007	003	002	003	000	004	000	003	000	005	015	000	004
1199	5-19-89	228	-	-	18	pass	008	000	002	002	020	004	000	009	001	000	001	142	018	040	004
1314	3-2-88	10	0	-	019	pass	005	000	005	003	006	003	000	006	000	003	003	131	017	011	004

AOAP Data from Ft. Sill Samples

Vehicle	Date	Since Ovhl	Since Change	Odom Read	Vis	H20	FE	AG	AL	CR	CU	MG	Ti	PB	SN	NI	MO	SI	NA	ZN	B
1314	8-18-88	58	48	-	015	pass	004	000	012	003	008	004	000	007	000	000	000	182	021	027	003
1314	12-29-88	77	67	-	019	pass	002	000	003	000	008	001	000	009	000	000	000	247	023	048	000
1314	1-13-89	82	1	-	019	pass	001	000	004	001	008	001	000	007	000	000	000	229	022	033	000
1314	02-22-89	82	1	805	018	fail	003	000	006	000	008	001	000	005	000	000	000	179	019	029	000
1439	5-6-88	660	660	-	017	pass	005	000	006	003	004	004	000	007	000	000	000	035	023	005	004
1439	3-9-89	694	694	-	18	pass	004	000	011	001	002	003	000	004	001	001	001	013	035	005	000
1439	1-16-90	-	-	111	19	pass	001	000	003	001	000	000	000	001	000	000	000	003	013	003	000
1672	1-11-88	629	0	-	019	pass	005	000	007	005	008	004	000	007	000	003	000	031	019	011	003
1672	8-18-88	739	110	-	016	pass	007	000	007	005	018	004	000	013	000	000	000	034	020	011	002
1672	12-29-88	761	132	5695	019	pass	004	000	003	002	010	006	000	005	000	000	003	014	017	009	000
1672	3-3-89	792	417	-	18	pass	005	000	004	002	009	000	000	003	000	001	000	012	019	003	000
1672	10-11-89	824	195	6052	18	pass	003	000	004	001	009	001	000	002	000	000	000	015	016	004	006
1791	5-6-88	652	652	-	017	pass	006	000	006	004	004	004	000	008	002	002	003	025	015	007	004
1824	5-20-88	618	618	-	017	pass	004	000	005	004	005	004	000	005	004	002	000	038	024	007	003
1824	3-2-89	-	-	-	19	pass	002	000	004	001	003	000	000	003	000	000	000	048	018	004	000
1824	10-17-89	716	716	4938	20	pass	003	000	006	002	006	001	000	008	001	000	001	072	018	012	000
1839	5-20-88	320	320	-	017	pass	004	000	005	004	004	004	000	007	000	003	000	010	032	007	003
1839	5-19-89	40		-	18	pass	012	000	003	003	003	003	001	003	000	001	001	060	023	009	00[illegible]
12033468	5-20-88	88	88	-	017	pass	004	000	005	004	009	004	000	010	000	002	000	087	022	029	003
12033468	03-02-89	131	131	-	20	fail	006	000	003	002	013	001	000	009	000	000	000	095	018	029	000
12033468	10-17-89	176	176	2146	020	pass	003	000	004	001	013	002	000	012	000	000	000	107	019	028	000

Appendix I
Data From Gravimetric Analysis of Samples Using 5.0 Micron Filter, as Used in Navy Patch Kit Test

Page No. 1
09/12/90

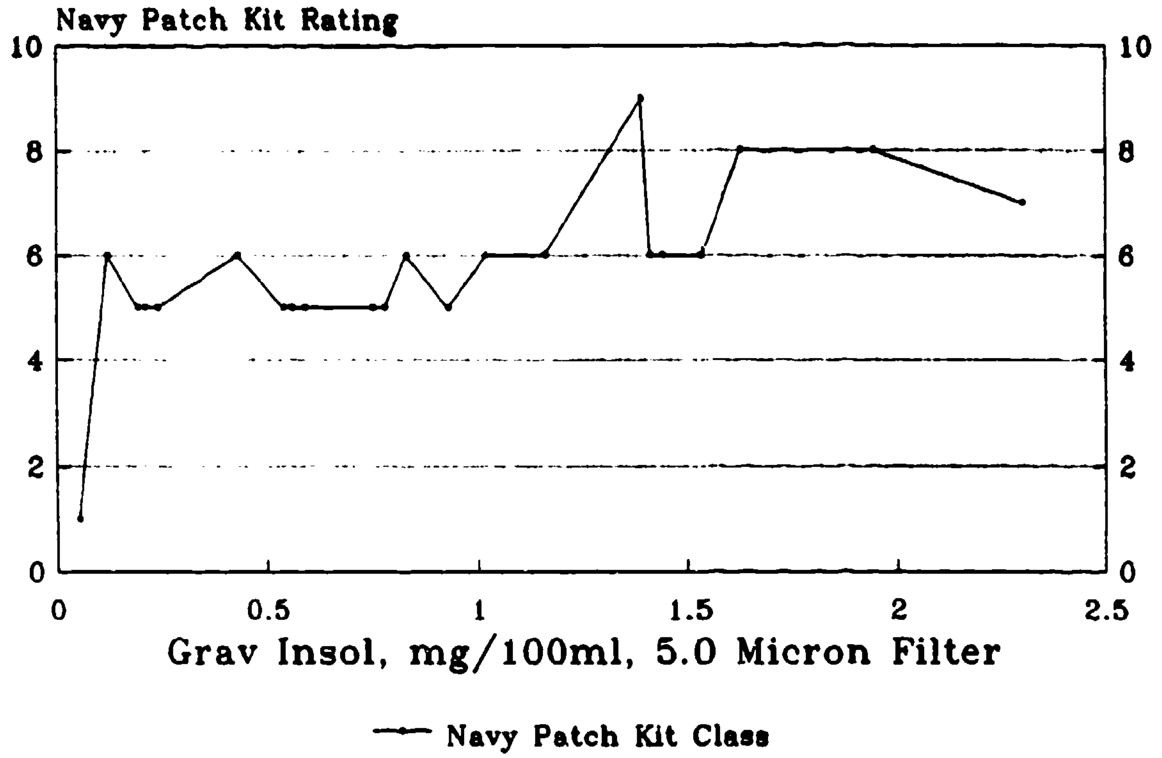
Data from Gravimetric Analysis of Samples
Using 5.0 Micron Filter, as is Used in Navy Patch Kit Test

Vehicle Number	Sample Date	Fluid Age	Grav Insol mg/100 ml 0.45 Micron Filter	Grav Insol mg/100 ml 5.0 Micron Filter	Visual Rating of Patch	NAVAIR 01-1A-17 Class	NAS 1638 Class	Particle Count 5-25 Microns	Particle Count 26-50 Microns	Particle Count 51-100 Microns	Particle Count Over 100 Microns
1439	09-29-89	13+month	0.23	0.05	pass,cl.1						
356	04-19-90	28 month	1.76	0.12	fail, cl.8	>6	>12	1,663,610	2,420	170	0
356	10-16-89	20 month	0.51	0.19	pass,cl.5						
1439	03-00-89	07+month	1.58	0.21	pass, cl.5	>6	Class 12	630,130	700	80	0
BWY501	04-12-90	04 month	1.68	0.24	pass, cl.5	>6	>12	1,277,580	3,750	230	0
1314	03-03-89	00 month	0.19	0.31	lost	>6	Class 12	867,110	1,890	150	10
1830	09-25-89	13+month	0.87	0.43	fail, cl.8						
356	03-03-89	13 month	1.03	0.45	lost	>6	Class 11	312,130	2,410	100	0
1314	04-19-90	03 month	0.40	0.49	fail,cl.10	>6	Class 8	58,990	6,010	1,290	160
1839	03-00-89	07+month	0.42	0.54	pass,cl.5	>6	Class 11	533,600	1,180	120	0
BWY 619	10-05-88	03 month	0.74	0.56	pass, cl.5						
1314	10-18-89	07 month	0.65	0.57	fail,cl.10						
BWY 619	04-11-90	07 month	1.12	0.59	pass,cl. 5	>6	>12	1,491,510	2,320	280	0
1199	09-25-89	16 month	0.89	0.65	fail,cl.10						
BWY501	03-01-89	06 month	3.53	0.73	lost	>6	Class 11	240,820	8,910	1,010	10
1672	04-19-90	03 month	1.50	0.74	fail,cl.10	>6	Class 11	801,760	7,840	1,220	40
241	03-00-89	11 month	0.86	0.75	pass,cl.5	>6	Class 11	468,280	2,660	390	10
1672	10-11-89	21 month	0.90	0.75	fail,cl.10						
171	04-23-90	26 month	2.04	0.76	fail,cl.10	>6	Class 12	930,270	4,380	620	20
FWC200	03-02-89	19 month	2.15	0.77	fail,cl.10	>6	Class 10	237,000	2,630	210	0
12D33460	09-27-89	01 month	1.21	0.77	fail,cl.10						
BWY 728	11-21-89	22 month	1.07	0.78	pass,cl. 5						
BWY 728	04-11-90	27 month	5.38	0.83	fail,cl.8	>6	>12	1,074,000	4,740	420	0
1824	03-02-89	07+month	1.69	0.89	fail,cl.10	>6	Class 10	278,320	5,750	410	0

Data from Gravimetric Analysis of Samples
Using 5.0 Micron Filter, as is Used in Navy Patch Kit Test

Vehicle Number	Sample Date	Fluid Age	Grav Insol mg/100 ml 0.45 Micron Filter	Grav Insol mg/100 ml 5.0 Micron Filter	Visual Rating of Patch	NAVAIR 01-1A-17 Class	NAS 1638 Class	Particle Count 5-25 Microns	Particle Count 26-50 Microns	Particle Count 51-100 Microns	Particle Count Over 100 Microns
BMY728	03-02-89	14 month	1.93	0.92	lost	>6	Class 10	261,180	3,790	80	10
1791	03-00-89	07+month	1.74	0.93	pass,cl.5	>6	Class 11	313,730	2,910	120	0
BMY 501	10-05-89	14 month	1.35	1.02	fail,cl.6						
BM 434	04-11-90	22 month	2.12	1.16	fail,cl.6	>6	Class 12	1,066,970	6,180	630	20
1199	03-17-89	09 month	0.74	1.39	fail, cl.9	>6	Class 12	180,810	27,150	420	10
1672	03-03-89	14 month	2.35	1.40	lost	>6	Class 10	270,090	1,170	160	0
BMY 434	11-21-89	17 month	2.23	1.41	fail,cl.6						
12D33468	03-02-89	16 month	1.66	1.44	fail,cl.6	>6	Class 11	334,460	9,200	430	10
BMY619	03-02-89	08 month	2.68	1.52	lost	>6	Class 10	251,440	2,470	220	10
BMY 434	03-02-89	09 month	2.56	1.53	fail,cl.6	>6	Class 12	176,270	21,830	1,240	40
1839	05-16-90	20+month	3.10	1.59	lost						
1824	09-27-89	13+month	2.09	1.62	fail,cl.8						
PCF 184	10-05-89	14+month	1.87	1.77	fail,cl.10						
1199	05-18-90	23 month	2.[illegible]	1.83	lost						
171	03-17-89	14 month	1.96	1.94	fail,cl.8	>6	Class 11	418,770	2,450	110	0
1824	05-17-90	20+month	4.26	2.25	lost						
FMC286	11-21-89	27 month	2.05	2.30	fail, cl.7						
PCF 184	04-11-90	05 month		26.76	fail,cl.9	>6	>12	37,370	55,070	65,960	xxx
2607	05-17-90	09 month		3.53	lost						
FMC 286	04-11-90	32 month	13.58.	4.84	lost	>6	Class 12	212,680	29,320	2,780	400
PCF184	03-06-89	07+month	8.49	8.87	lost	>6	Class 12	136,790	25,540	3,800	160

Appendix J
Correlation of Gravimetric Insolubles



Navy Patch Kit Rating: Classes 1, 3, 5 are passes
6 = fail; 7, 8, 9 are worse than 6

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